SIMULATION OF LAGRANGIAN DRIFTERS IN THE LABRADOR SEA

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LONG-TERM GOALS

The long-term goals of the Oceanic Planetary Boundary Layer (OPBL) Laboratory are to understand the role of the OPBL in exchanging momentum, mass and energy between the ocean and the atmosphere, and to build and verify realistic models for OPBL processes in ocean circulation and air-sea interactions.

OBJECTIVES

The purpose of this study is to understand the motion and sensor response of drifting packages of scientific instruments in the Office of Naval Research's Accelerated Research Initiative (ARI) on Deep Oceanic Convection in the Labrador Sea. Understanding the drifter response will lead to optimal strategies for deployment of drifting instruments, and it will help in the interpretation of observations obtained by instruments under the influence of oceanic convection. A key scientific objective is to understand the turbulent kinetic energy budget for free and forced deep oceanic convection, and the processes leading to deep penetrative convection in subpolar seas.

APPROACH

The method is to use nonhydrostatic oceanic large-eddy simulation (LES) to predict the unsteady three-dimensional turbulent velocity, temperature, salinity, and pressure fields on a model grid (typically in a domain of order 1-4 km deep and 3-12 km horizontal dimensions) that resolves the OPBL and the turbulence from the integral scale (dominant eddy size) through the inertial range. These fields are archived or used directly to advect Lagrangian drifter models (LDM's). LDM's may be designed to simulate a variety of drifter designs: pure Lagrangian, isobaric, glider, or propelled (AUV's).

WORK COMPLETED

During the past year a systematic study of deep OPBL's in equilibrium with steady forcing, varying from free convection to forced convection has been completed. A technical report (Harcourt *et al*. 1997) was published showing the response of isobaric and pure Lagrangian LDM's to these deep convection fields.

RESULTS

LES has been used to show that isobaric (Rossby-type) drifters will sense mean fields for temperature and velocity that will be biased by the tendency for the fixed-depth drifters

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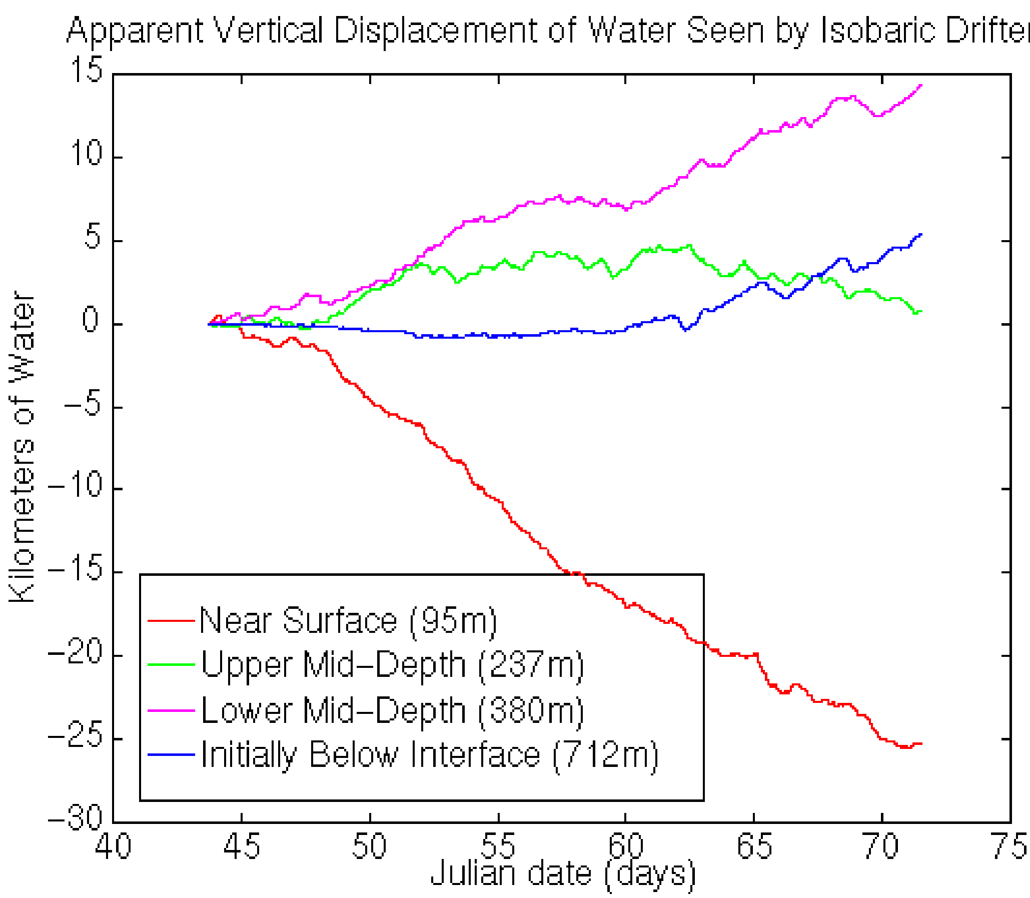
to seek out and maintain position in zones of horizontal convergence. Depending upon the ballasting depth, these drifters will experience a significant mean vertical velocity that is caused by the turbulence, not by a true mean upwelling/downwelling. Figure 1 shows that nearly 15 km of water is advected vertically *upward* past an isobaric drifter simulated to be ballasted to drift at the 380-m depth during 28 days of simulated Labrador Sea convection during February-March 1997. In the same simulation, more than 25 km of water is advected *downward* past a drifter at the 95-m depth. This result is very important for (i) suggesting strategies for drifter deployment, and (ii) understanding the results from the ONR ARI on deep convection that was just completed (winter 1997). An important corollary result is that the isobaric float-observed fluxes may be corrected by a predictable structure function, calculated by large-eddy simulation. The organized structure of the turbulence varies from Rayleigh-Benard cells to horizontal rolls, depending upon the relative strength of the buoyancy forcing compared with the wind forcing.

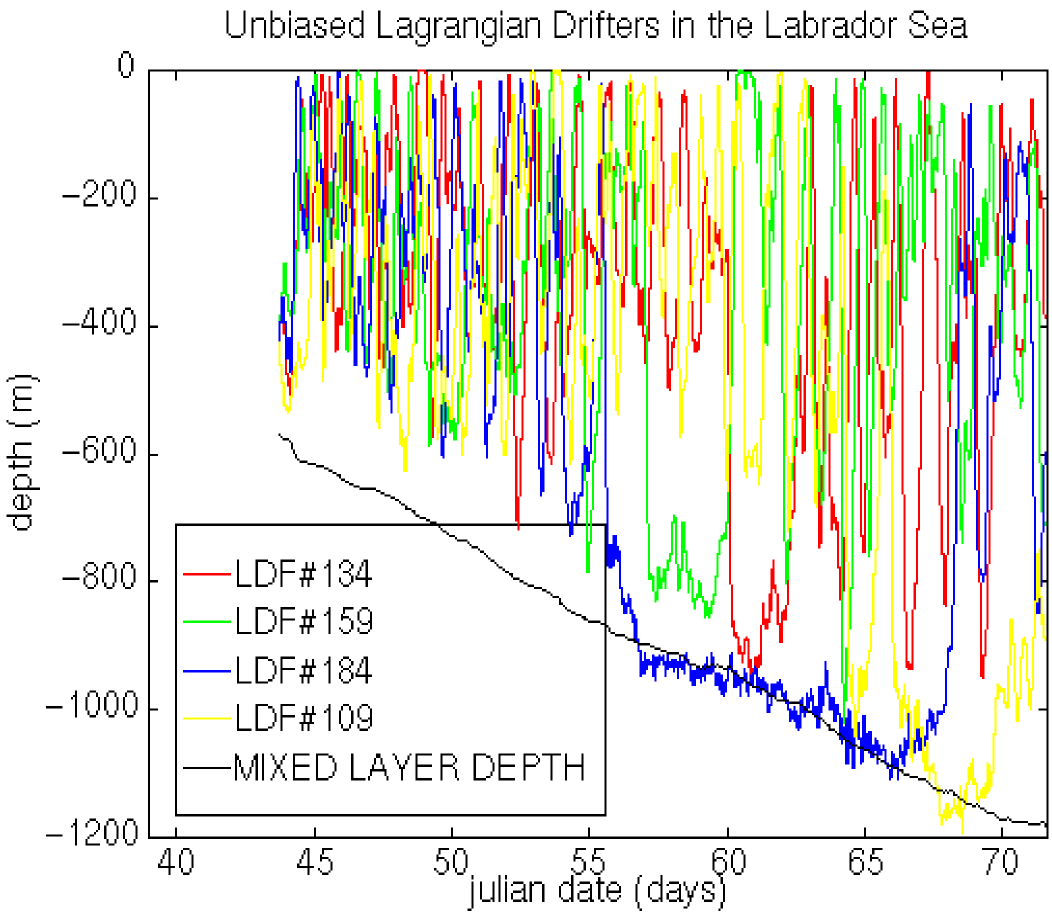
Figure 1.



Observations of velocity and temperature by purely Lagrangian drifters (Figure 2) will not be biased; however, actual drifters will not always perform ideally, and realistic LDM's for these drifters are being constructed which will assist in the analysis of the field data provided by these drifters. In Figure 2, one of the idealized "perfect" unbiased Lagrangian drifters was temporarily detrained from the OPBL and later re-entrained.

This may or may not happen with real drifters, depending upon drifter design.

Figure 2.



During the 28-day period of the simulation depicted by Figures 1 and 2, the mixed layer deepened from less than 600 m to below 1100 m. The model-simulated LDM results for the 1997 Labrador Sea experiment will be compared with actual drifter observations, as they become available.

TRANSITIONS

These results concerning the advection of freely-drifting bodies have direct implications for the conduct of mine warfare and mine warfare countermeasures. The LES model also has important future application in the nearshore and coastal zones because of the need to include nonhydrostatic acceleration over ocean topography that has significant slope.

RELATED PROJECTS

The OPBL Laboratory also has support from the National Science Foundation to study Polar Sea Conditional Instabilities. This project examines processes that may lead to bottom water formation, including thermobaric parcel and layer instabilities (Garwood adn Guest, 1996; Garwood and Harcourt, 1997), and the interaction between mesoscale motion and plume-scale turbulence in forming three-dimensional bottom plumes (Jiang and Garwood, 1996).

Another OPBL Laboratory project is “Tropical Mixed Layer System,” sponsored by NOAA and NSF. In this project turbulence closure is used to parameterize mixed layer dynamics in basin-scale OGCM’s, examining such processes as the interaction between equatorial shear zones and turbulent mixing layers, as a function of surface forcing anomalies such as westerly wind bursts, strong precipitation events, and anomalous wind forcing associated with El Niño.

REFERENCES

Jiang, Lin, and Roland W. Garwood, Jr., “Three Dimensional Simulations of Overflows on Continental Slopes,” Journal of Physical Oceanography, Vol. 26, No. 7, 1214-1233, July 1996.

Garwood, Roland W., Jr., and Arlene A. Guest, “Greenland Sea Convection Instabilities,” Report of the First ACSYS SEA-ICE/OCEAN MODELLING WORKSHOP, Hamburg, Germany, 13-15 December 1993, World Climate Research Programme, WCRP Report No. 12, Ed. by P. Lemke, October 1996.

Garwood, Roland W., Jr., and Ramsey R. Harcourt, “The Oceanic Planetary Boundary Layer in the Polar Seas,” Workshop on Polar Processes in Global Climate, Cancun, Mexico, 13-15 November 1996, American Meteorological Society, 4.2, 4 pp., in press 1997.

Harcourt, Ramsey, Lin Jiang, and Roland W. Garwood, Jr., “Numerical Simulation of Drifters Response to Labrador Sea Convection,” Naval Postgraduate School Technical Report NPS-OXC-97-003, Prepared for the Office of Naval Research, Code 322OM, 70 pp., June 1997.

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